Continuing Research Preliminary Proposal - Study Code: ADS-P-00-6

Evaluation of steelhead kelt passage through the second powerhouse Bonneville Dam (B2) prior to the juvenile migration season.

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PROJECT SUMMARY

Successful expression of iteroparity in steelhead *Oncoryhnchus mykiss* populations may be limited by migration delay and passage events associated with navigating through hydroelectric dams (Wertheimer and Evans 2005; Wertheimer in-press). Bonneville Dam (BON) - the lowermost hydroelectric project on the Columbia River - creates the sole FCRPS reservoir affecting both winter (ocean maturing) and summer (stream maturing) steelhead varieties (Busby et al. 1996). Studies indicate that both steelhead varieties spawn in BON pool tributaries from December to April (Howell et al. 1985; CTB et al. 1990; McMillan 2001; Bair and Weiman 1995), prior to the juvenile salmon passage season (FPP 2006). Because some steelhead out-migrate immediately after spawning (Shapovalov and Taft 1954) providing optimal migration routes through BON during the period of steelhead spawning should bolster return rates from these fish. The **goal** of this study is to quantify kelt use of the BON second powerhouse corner collector - B2CC- prior to the juvenile salmon passage season. Our study objectives include:

Objective 1. Enumerate the level of kelt use of the B2CC to determine whether operations during March are warranted.
Objective 2. Evaluate kelt entrance behaviors at the B2CC
Objective 3. Compare return rates between kelts passing B2CC v. B2 JBS.

Methods: We propose to use the downstream passive-integrated-transponder (PIT) detection system at the B2CC, hyroacoustic monitoring, and a DIDSON camera to passively enumerate and determine entrance behaviors of downstream migrating kelts. Kelt passage through the B2 juvenile bypass system (JBS) will also be quantified through PIT detections. Because winter steelhead migrate upriver in a sexually mature state, typically from November through April (Withler 1966), we intend to PIT-tag steelhead at the BON Adult Fish Facility (AFF) during this period. Tagging during this period at the AFF is designed to target steelhead spawning in BON pool tributaries. Upriver migrating steelhead pre-spawn adults will be tagged in the Wind, Hood, and Klickitat rivers to quantify B2CC kelt passage prior to operations for juvenile salmon and determine the steelhead return rates. Steelhead that had been originally tagged as outmigrating smolts, one to three years previously, will also supplement our sample. Because the B2 JBS will provide PIT monitoring after 1 March, operating the B2CC during March will allow PIT-tagged kelt enumeration, and evaluation of the return rates from kelts passing the B2CC in relation to those passing via JBS. In the absence of spill, data indicate that over 90% of kelts at BON will pass B2. Of kelts passing B2, almost 90% of these are expected to pass via the B2CC, and roughly 6% via the B2 JBS (Wertheimer in-press).

Relevance: The National Marine Fisheries Service (NMFS) recognizes the potential value of kelts for achieving rebuilding goals (NMFS 2000), and has requested that research be conducted to evaluate and reduce dam passage mortality of *kelts.* The NMFS's 2000 Biological Opinion Reasonable and Prudent Alternative (RPA) 109 states: *The corps shall initiate an adult steelhead downstream migrant (kelt) assessment program to determine the magnitude of passage, the contribution to population diversity and growth, and potential actions to provide safe passage.*

PROJECT DESCRIPTION

Background: The declines of Columbia River basin steelhead *Oncoryhnchus mykiss* populations have led to listings under the U.S. Endangered Species Act (ESA) of 'threatened' for the Snake, lower & mid-Columbia Rivers' stocks, and 'endangered' for the upper Columbia River stocks (NMFS 2004). Causes for these declines include, but are not limited to, exploitation rates, land use practices, hatchery supplementation, ocean conditions, and hydroelectric impoundment effects (Raymond 1988; Waples 1991; ISG 1999; Wertheimer and Evans 2005). Reduced genetic contributions from steelhead stocks formerly supplemented by repeat spawners may play an important role in the decline of Columbia Basin steelhead populations (NMFS 2000). The proximity of steelhead spawning in BON pool tributaries to the Pacific Ocean indicates the seasonal timing of surface bypass route operations through BON powerhouse areas should be evaluated to best enhance the return rates from these fish. This is particularly true at the B2CC, which passed over 80% of kelts at B2 in 2004; generating an effectiveness value (fish-to-flow) in excess of 16:1. Such data suggests a cost-effective use of typically limited water supplies to enhance iteroparity rates, thereby aiding ESA listed lower Columbia River steelhead stocks. Moreover, information suggests that surface flow bypass systems such as the B2CC provide the most benign passage routes for kelts at dams and could aid the return rates from these fish (Wertheimer in-press).

As the lowermost Columbia River project, BON passes a larger number and more diverse variety of anadromous migrants than any of the other main-stem dams, thereby having the potential to have the most deleterious impact to anadromous fishes. For instance, iteroparity rates of populations of summer and winter steelhead varieties in the Kalama River (a tributary downstream of BON) were estimated at over 15% and over 21%, respectively (Withler 1966; Leider et al. 1986). In comparison, iteroparity rates of summer and winter steelhead populations in the Hood River (a tributary to the BON pool) have been reported at over 9% and over 13%, respectively (Olsen 2004). While a variety of factors affect steelhead iteroparity rates; evidence indicates indirect (e.g., migration delay) and direct (e.g., shear, strike) effects related to BON passage negatively affect the return rates from BON pool steelhead (Wertheimer et al. 2001, 2002, 2003; Madson et al. 2004). Both the B2CC and B2 JBS have PIT detection capabilities, allowing passive monitoring for PIT-tagged fish. Concurrently, we propose to use hydroacoustics and a DIDSON camera to enumerate kelt passage and evaluate the behaviors of kelts entering the B2CC. After-tagging, data will be uploaded to *Ptagis* using established protocols.

OBJECTIVES

Objective 1. Enumerate the level of kelt use of the B2CC to determine whether operations during March (potentially earlier) are warranted.

Objective 2. Evaluate kelt entrance behaviors at the B2CC

Objective 3. Compare the return rates between kelts passing the B2CC v. those passing the B2 JBS.

METHODS

Fish for this evaluation will come from multiple sources, including:

1) Adult steelhead collected at BON AFF and outfitted with PIT tags,
2) Adult steelhead collected and outfitted with PIT-tags as returning adults at the Wind River, Shipherd Falls ladder during their upstream spawning run.
3) Adult steelhead collected and outfitted with PIT-tags as returning adults at the Hood River, Powerdale Trap during their upstream spawning run
4) Adult steelhead collected and outfitted with PIT-tags as returning adults at the Klickitat River, Lyle adult trap during their upstream spawning run
5) Adult steelhead that had been originally tagged as outmigrating smolts one to three years previously.
6) Untagged steelhead that originally migrated as smolts one to three years previously (i.e., hydroacoustic and DIDSON monitoring).

It is anticipated that a portion of the fish from these groups will pass downstream as kelts and be detected via PIT at BON and B2 (B2CC & B2 JBS). We propose to supplement PIT detections at the B2CC with hydroacoustic monitoring. We also anticipate capturing imagery of kelt entrance behavior at the B2CC with a DIDSON camera. Subsequently, B2CC PIT detection for passing kelts will allow verification of captured DIDSON imagery. It is plausible that imagery from the DIDSON could aid in identification of some of the sensory stimuli these fish are reacting to and behaviors kelts are displaying during entrance into the B2CC (e.g., positive and/or negative rheotaxis, schooling), providing data to refine entrance criteria at a surface flow bypass for steelhead kelts.

Objective 1. Enumerate the level of kelt use of the B2CC to determine whether operations during March (potentially earlier) are warranted.

Task 1.1: PIT- tag upstream migrating winter steelhead at the BON AFF: Sampling at BON will occur daily from 1 November through March. Fish will be collected at the Adult Fish Facility (AFF) adjacent to the Washington-shore fishway. During the first half of November when appreciable numbers of fall Chinook salmon are still passing the project the trap will be manned approximately 10 hrs per d. Each morning during this period, picket leads will be lowered into the fishway, diverting all fish in a bypass ladder that leads into the AFF head tank. Fish swim from the head tank into one of two exit chutes through false weirs and slide down wetted chutes. Steelhead to be sampled is diverted into an anesthetic tank (clove oil, ~22 mg/L) via manually controlled electronic slide gates. Once anesthetized (2 to 4 minutes) fish are placed into a wetted, vinyl-coated sleeve and moved to a smaller tank where lengths, weights, fish condition (poor, fair, good) and presence of marks, clips, and injuries are recorded. Each fish will be scanned with an ultrasound to confirm maturation status and for PIT tags. If one is not present a PIT tag (12 x 1 mm) will be inserted to the dorsal sinus using hand injector and the fish will be moved to the brail pool for recovery. Once recovered from anesthesia, tagged fish will be able to volitionally leave the brail pool and return to the fishway to continue their ascent of the dam. Sampling generally requires 4 to 6 min per fish and the fish are anesthetized and submerged at all times except when moved between tanks and when measured for length and weight. When numbers of fish decline to low numbers (< 100

per d at the dam), around mid-November, we propose to operate the trap 24 hr/d. In this sample mode, all fish that pass through the trap during off hours are diverted to the brail pool. In the morning, project personnel work up the fish diverted since the previous evening, and then operate the trap as described above, tagging fish as they arrive. Since salmonids are primarily active during daylight hours relatively few fish will be diverted when personal are not present. Target sample size for this tagging effort is 1,000 to 2,000 female winter steelhead PIT-tagged at BON.

Task 1.2: PIT-tag Hood River summer and winter steelhead at the Hood River Production Program Facilities: Wild summer and winter steelhead collected as broodstock for the Hood River Production Program will be PIT tagged and released into the Hood River subsequent to spawning or if no longer needed for hatchery broodstock purposes. Broodstock will be randomly collected throughout the wild component of the summer and winter steelhead runs escaping to the adult fish facility at Powerdale Dam (RM 4.5) on the Hood River. A fish ladder on the east bank of Powerdale Dam diverts adult salmonids into a temporary holding area where they are crowded into a fish lock and elevated into the working area of the trapping facility. In the working area of the trapping facility, fish are transitioned from the fish lock to a staging tank; from the staging tank to an anesthetic tank (CO_2); and from the anesthetic tank to the sampling area. Adult steelhead are identified by species, race, and gender and are classified as either wild, subbasin hatchery, or stray hatchery based on the fin and maxillary clip combination and scale analysis. Subsequent to the physical examination, hatchery broodstock will be measured to the nearest 0.5 cm, weighed to the nearest 0.1 kg, scanned for PIT tags, and have a scale sample removed. Broodstock will then be transported to a holding and spawning facility near the city of Parkdale where the fish will remain until they are sexually mature. At maturity, broodstock will either be spawned and released into the Hood River, or released unspawned into the Hood River (Olsen 2004). If no PIT tag is detected, a hand injector will be used to insert a PIT tag (12 x 1 mm) into the dorsal sinus. Fish will be moved to a liberation tank for recovery and transported to either the mouth of the Hood River (spawned females) or just upstream of Powerdale Dam (spawned males and unspawned broodstock). Spawning will occur from February to May for summer steelhead and from April to May for winter steelhead. Sample size will vary annually depending on the population of adults escaping to Powerdale Dam.

Task 1.3: PIT-tag Klickitat River winter steelhead at the Lyle adult trap. Klickitat River adult summer and winter steelhead will be collected at Lyle Falls Fishway (RM 2.2). The YKFP is currently using the Lyle Falls Fishway to collect biological information and escapement estimates for salmonids present in the Klickitat Subbasin. Wild summer and winter steelhead are collected via this volunteer fishway. Estimates of fish use of the ladder range between 5 -30%, dependent on river stage. Based upon past data we expect to PIT- tag 300-500 steelhead, split evenly between summer peak (July - Sept) and the winter peak (Jan-Apr).

On a daily basis, or as a function of fish recruitment, salmonid passage is monitored at Lyle Falls Fish Fishway. Fish are netted with in the trap chamber, placed in black-out

tubes (pvc ½ tubes with single closed end, used for holding fish's head in water while sampling), sampled for length, scales, DNA and hatchery steelhead are floy tagged. Under current operation trapped fish are not anesthetized due to harvest and human consumption concerns. Trap operation began in June 2004 and continues year –round, with minor periods of interruption during extreme high water. In 2005, over 1,000 combined steelhead were handled for sampling.

Task 1.4: PIT-tag Wind River steelhead at the Shipherd Falls ladder: As part of intensive monitoring effort in the Wind River, WDFW has operated an adult trap at the Shipherd Falls ladder since 1999 (Rawding and Cochran 2006). The primary purpose of trap operations is to estimate the population of steelhead above Shipherd Falls and to collect biological information such as age, length, timing, and origin from returning salmon and steelhead. The proportion of steelhead using the ladder is dependent on flow and temperature. From November through April ~ 100% of steelhead adults use the ladder but from May through October the proportion is likely reduced to ~20% to 50%. The adult trap is left open during the month of May, when few adult steelhead were present and because limited resources do not allow for sampling the large return of hatchery spring Chinook salmon.

The adult trap is operated on a daily. Fish are netted from the trap and placed in an anesthetic solution. After steelhead have "calmed down", they are sampled. Sampling procedure includes obtaining scale samples, and other biological information such as length, origin, fin condition, and sex. Fish are then scanned for coded-wire-tags (CWT) and PIT tags. Finally, fish are double Floy tagged to obtain mark-resighting estimates (Rawding and Cochran 2005). Fish are released into a recovery chamber upstream of the trap and volitionally exit the ladder when sufficiently recovered.

Task 1.5 Estimate the numbers and distribution of kelt-sized fish that pass at the B2CC: We will also sample kelt entering the B2CC with traditional hydroacoustic equipment using the same methods used in 2004 and 2005 (Ploskey et al. 2005, 2006). This will involve locating six split-beam transducers on a vertical pipe about 20 ft to the southeast of the entrance of the B2CC on a barge so that acoustic beams can be aimed across the entrance. Fish will be detected mostly in side aspect, thereby maximizing signal to noise ratios and fish detection (Figure 1). The pipe supporting the vertical array of six transducers will be rotated to aim acoustic beams about 12-15 ft upstream of the entrance where flows will be sufficient to capture smolts (8-10 ft / s) but low enough to allow adequate detectability. With a ping rate of 37 pings / s, a fish moving 10 ft / s through the center of an acoustic beam would provide 7 echoes if it passed into the entrance on the south side and 13 echoes if it passed on the north side. Four echoes are the minimum required to classify an echo trace as a fish. The upper two split-beams will have nominal 3-degree acoustic beams to minimize volume reverberation, which typically is worst near the surface. The lower four transducers will have nominal 6-degree acoustic beams. The count of every detected fish will be spatially expanded by the ratio of the height of the rectangle it samples to the diameter of the acoustic beam at the range a fish is detected. Whenever forebay elevations range from EL 74.1-76.0 ft, the deployment will provide passage distribution data within 11 1.85 ft vertical strata in the upper 20.35 ft of the water

column and within one variable 1.85-3.75 ft strata below that depth. When forebay elevations are between EL 70.5 and 74.1 ft, the deployment will provide passage distribution data within 10 1.85 ft vertical strata in the upper 18.5 ft of the water column and within a 4.5 ft stratum below 18.5 ft. The vertical resolution is possible because tracked fish can be classified as being in the upper or lower one half of the beam. Laterally, the deployment will provide estimates of passage distribution to the nearest 0.5 ft across the 15-ft wide entrance. Wide band hydroacoustic sounders will be used to sample the sluice entrance. A problem with sampling sluiceway entrances is that fish densities can sometimes be so high that typical hydroacoustic gear with pulse widths of 200 μs cannot resolve all individual fish unless they are ≥ 6 inches apart. This problem was encountered at a B1 sluiceway entrance in summer 2002 (Ploskey et al. 2003). The split-beam transceivers used to sample the B2CC in 2004 (Ploskey et al. 2005) had their bandwidth increased from 20 to 100 kHz and pulse widths shortened from 200 to 80 μs to reduce the target resolution distance from about 6 inches to about 2.36 inches, where resolution distance is the minimum range between resolvable targets.

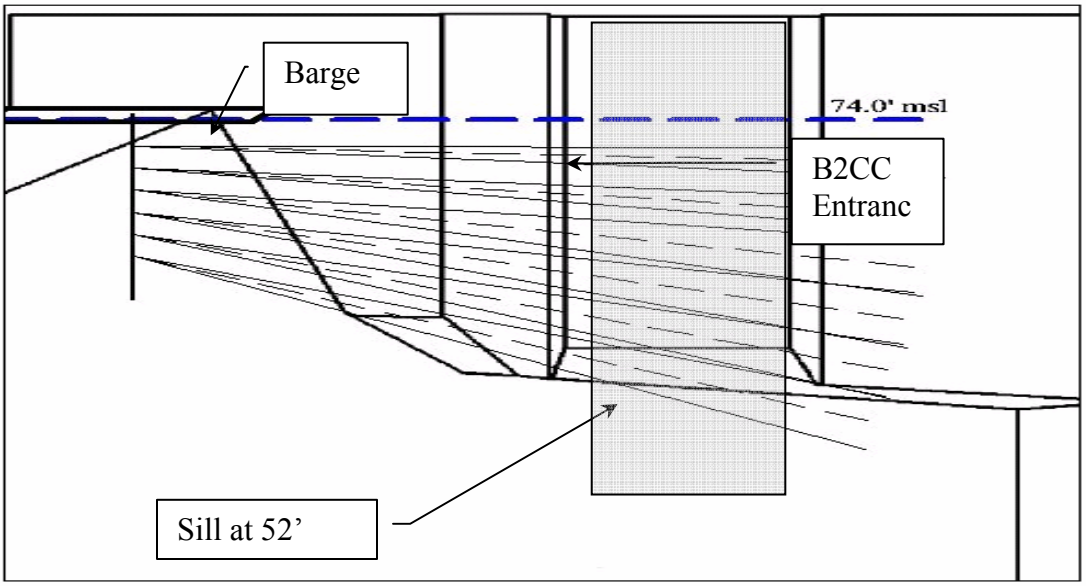

Figure 1. Diagram of a Frontal View of the B2CC Entrance Showing the Acoustic Beams from Six Split-beam Transducers Deployed from a Barge East of the Entrance. Minimum and maximum ranges for tracking fish were 15 and about 29.5-36 ft (depending upon the beam), respectively.

Objective 2. Evaluate kelt entrance behaviors at the B2CC

Task 2.1: Sample at the entrance of the B2CC with a DIDSON acoustic camera to acquire data of kelt swim paths as they approach and enter, or swim away from, the B2CC:
We will use a DIDSON acoustic camera to record kelt paths immediately upstream of the B2 Corner Collector during the kelt outmigration period similar to methods used in 2004 to evaluate passage of salmon smolt into the B2CC (Ploskey et al. 2005). The DIDSON will be aimed just upstream of the weir and a rotator used to adjust the orientation of the DIDSON relative to the B2CC entrance due to changes in forebay water level (Figure 2).

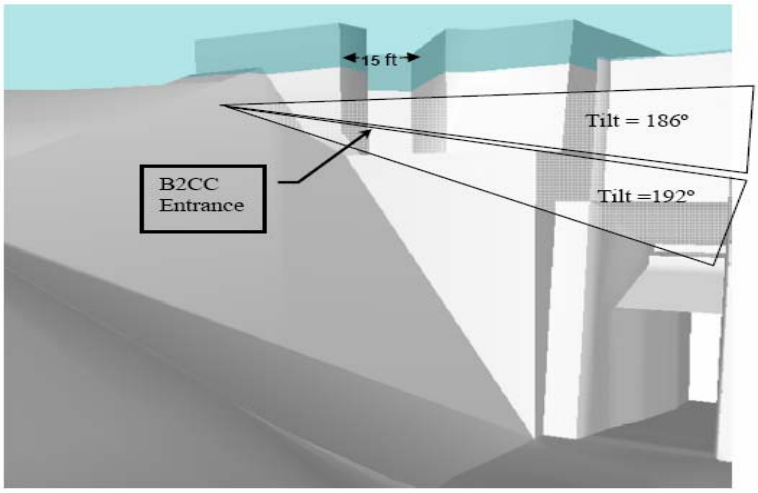

Figure 2. Orientation of the DIDSON relative to the B2CC. The DIDSON will be mounted on a barge as described below for the hydroacoustics.

We will estimate the proportion of kelt entering the B2CC relative to the proportion that find the B2CC but swim away from the entrance. We will also evaluate the schooling behavior of kelt vs. kelt passing individually through the B2CC. Finally, we will attempt to correlate a kelt imaged on the DIDSON with PIT tag detected kelts in the B2CC.

Task 2.2: Process and analyze the fish movement and flow data collected in 2004 and 2005 to quantitatively describe fish behavior by size class and determine effects of hydraulic conditions by fully integrating and analyzing fish and flow data: Data will be processed and analyzed.

Objective 3. Compare the return rates between kelts passing the B2CC v. those passing the B2 JBS.

Task 3.1 Data processing: Downstream (B2CC, JBS) and upstream (BON fishway) detections will be retrieved from Ptagis to calculate proportional use of each downstream route and proportion return rates by downstream route. Data will likely need to be arcsine transformed to use logistic regression analysis to evaluate if tagging location, fish size, passage date, and passage routes are statistically associated with the odds of returning to spawn again. MANOVA analysis will be used to evaluate possible differences in fish size, age, and location (i.e., tributary) between repeat spawners and the non-returning steelhead population. All statistical tests will be run using SAS[1](r) version 8 and will be significant at the alpha = 0.05 level.

FACILITIES AND EQUIPMENT

At the BON AFF and the Wind, Hood, and Klickitat rivers, suitable sampling locations and protocols are established and have used during previous years. At the AFF, equipment necessary for tagging operations will be prepared and supplied by University of Idaho, whereas, equipment for sampling in the various tributaries will be prepared and supplied by the respective agency (i.e., WDFW, ODFW, and the YKFP). All necessary permits will be acquired prior to the sampling period.

IMPACTS

Operation of the B2CC has the potential to raise total-dissolved-gas (TDG) to beyond acceptable levels for Chum salmon (*Oncorhynchus keta*) spawning in the Ives - Island area beyond BON. However, the affect of such springtime B2CC operations on TDG are unclear. To address the need for such data, a concomitant evaluation of effects of TDG on Chum salmon fry (*SPE-P-06-1*) will initiate earlier (on or before 1 March) and sensors will be placed in proximity to existing and new redds to quantify B2CC operational affects on TDG levels and chum salmon fry and redds.

REPORTING

We will provide monthly updates of field activities and results (if available) directly to the Corp appointed POC. A draft annual report describing results of this project will be submitted to the funding agency by December 31 of each calendar year. A final annual report, which will incorporate comments from AFEP reviewers, will be submitted by March 31 of the next calendar. We will also prepare the necessary reports required by permitting agencies and give presentations to regional resource management agencies, as requested by the funding agency (e.g., Annual AFEP Review meeting). Deliverables in optional years (i.e., annual reports, presentations to regional managers, etc.) will follow the schedule outlined above, to include a final project completion report due one year after the completion of all field work.

KEY PERSONNEL AND DUTIES

Robert Stansell (COE - FFU: Team Leader). Oversees study design, data analyses, and report writing/editing.
Robert Wertheimer (COE - FFU): Oversees the work including experimental design, fieldwork, and reporting.
Dr. Chris Peery (UI – ICFWRU): Oversees the work including experimental design, fieldwork, report writing, and presentations.
Rob Reagan (ODFW): Responsible for planning, directing and coordinating PIT-tagging of Hood River steelhead and reporting.
Joseph Zendt (YKFP): Responsible for planning, directing and coordinating PIT-tagging of Klickitat River steelhead, and reporting.
Dan Rawding (WDFW): Oversees Shipherd Falls trap operation on the Wind River.
Patrick Cochran (WDFW) Wind River PIT-tagging and data compilation.
Mark Weiland (PNL): Responsible for planning, directing, deploying DIDSON and Hydroacoustic gear and data analyses and reporting.
Bill Nagy (COE -FFU): Post processing of DIDSON imagery and hydroacoustic targets.
Sean Tackley (COE- FFU): PIT-tagging, data analysis and data compilation.

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